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Final Report: Radar Data Gathering on M.V. Arctic

Prepared For:
Transportation Development Centre
Policy and Coordination Group
Transport Canada

Prepared by:
Canarctic Shipping February 1990

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Un sommaire en français de ce rapport est inclus avant la Table des matières.

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16. Abstract

The late fall M.V. Arctic voyage to the Canadian Arctic was chosen as an opportune time for dedicated radar data collection. In order to collect adequate marine radar data, high digitizing rates and high bandwidths were required of the data collection system. Nordco Ltd.'s newly developed data acquisition system was chosen for this purpose, and the system was installed on board the M.V. Arctic in Antwerp, Belgium in early November 1989. After crossing the North Atlantic Ocean, data collection began in the southern part of Baffin Bay. Numerous radar images were recorded of different ice environments, at different radar settings. A total of 13 high precision and high density sets of radar images were collected, totalling approximately 4 Gbytes of data and recorded on 8mm video tape using an EXABYTE(R) digital data storage drive. Most of the collected images can be correlated to SAR (Synthetic Aperture Radar) images of the same area, received via downlink on board the vessel at the time of data collection. The report describes the intent of the collected data sets, and the full characteristics of each file are given.

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16. Résumé

Le dernier voyage saisonnier du N.M. Arctic dans l'Arctique canadien fut choisi dans le but d'une collecte d'images radar. Pour ce faire, un système capable d'un taux élevé d'échantillonnage et possédant une large bande passante était requis. Un système nouvellement développé par Nordco Ltée fut choisi pour cette mission, et le système fut installé à bord du N.M. Arctic à Anvers en Belgique, au début de novembre 1989. La cueillette des données commença au sud de la baie de Baffin, après la traversée de l'Atlantique nord. Un grand nombre d'images radar furent enregistrées, représentant différents environnements de glaces et des paramètres d'opération différents. Un total de 13 groupes d'images radar de haute précision et haute densité furent enregistrés, totalisant en excès de 4 gigabytes de données. Ces données furent stockées sur ruban magnétique vidéo 8 mm à l'aide d'une unité de stockage numérique EXABYTE(R). La majorité des images enregistrées peuvent être comparées à des images SAR <<Synthetic Aperture Radar>> de la même région, reçues à bord du navire durant le voyage. Ce rapport décrit le but de chaque groupe d'images et toutes les caractéristiques de chaque fichier de données sont fournies.

17. Mots clés	18. Diffusion
Radar, SAR, navigation dans les glaces, polarisation verticale, images radar, système d'acquisition de données	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

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Executive Summary

Many ice navigation research projects depend on the availability of high quality radar images of ice. Such projects as Marine Radar Image Enhancement Phase III, and SINSS Second Generation System, require unprocessed high resolution radar data of ice environments. The November voyage of the M.V. Arctic into the eastern Canadian Arctic constitutes an ideal opportunity to collect marine radar data of a variety of ice conditions. During the November voyage, the ship traditionally encounters the full range of possible ice conditions and, in addition, a good part of the encountered environments can be correlated with SAR imagery. It was thus decided to set up a data collection effort during the 1989 M.V. Arctic last voyage to Nanisivik, N.W.T.

The successful collection of high quality marine radar images of the ice environments is dependent on the digitizing rate and the bandwidth of the data collection system. A system capable of acquiring the required data was found at Nordco Ltd. of Newfoundland, where a prototype system was functional and required testing. The system was shipped to Antwerp, Belgium, where it was installed on board the M.V. Arctic. Various adjustments and modifications were made to the Canarctic Marine Radar system to connect the Nordco system and ensure the highest quality data.

The ship left Antwerp on November 8, 1989, and proceeded to Nanisivik across the North Atlantic Ocean. The dedicated data collection began when the vessel reached a latitude of 71°N in southern Baffin Bay, on November 15, 1989. A large quantity of marine radar images of various ice conditions were recorded at different radar settings. Images were recorded of both a moving and a static environment, from the three onboard radar sources: the Decca X-Band, the Sperry X-Band HH, and the Sperry X-Band HV.

A majority of the collected radar images are correlated to received SAR images of the same area.

The complete technical specifications of each collected data file have been recorded on log sheets and are repeated at the beginning of each data file. The collected data are divided in 13 data sets, plus a variety of unrelated general purpose data files. A total of 4 gigabytes of data has been collected and recorded on 8mm video tapes, using an EXABYTE(R) tape drive. The intended use of each data set has been outlined and suggestions are given for further analysis of the collected data.

The collected data constitute an unprecedented set of high precision and high bandwidth radar information. This data set consists of more than 4 gigabytes of raw radar video information that can be processed to extract the desired information. No processing has been performed on this data, and it has not been altered in any way. Analysis of the collected information can now be undertaken, using processing that ranges from different scan conversion techniques to the most innovative image processing algorithms.

Sommaire

Plusieurs projets de recherche dans le domaine de la navigation dans les glaces sont tributaires de la disponibilité d'images radar de haute qualité. Des projets tels que le "Marine Radar Image Enhancement Phase III" et le "SINSS Second Generation System" requièrent des images radar brutes à haute résolution. Le dernier voyage du N.M. Arctic dans l'est de l'Arctique canadien, constitue la meilleure occasion de procéder à la collecte d'images radar pour la navigation dans les glaces. Coutumièrement pendant le voyage de novembre, le navire traverse la gamme complète des différentes conditions de glace possibles. De plus, une bonne partie des images enregistrées peuvent être comparées aux images SAR <<Synthetic Aperture Radar>> habituellement reçues durant ce voyage. Il fut donc décidé d'organiser une collecte de données radar durant le dernier voyage du N.M. Arctic vers Nanisivik (T.N.O.) en 1989.

La qualité des images radar des glaces dépend du taux d'échantillonnage et de la bande passante du système d'acquisition de données. Un système capable de la performance requise fut trouvé à Terre-Neuve, chez Nordco Ltée, qui venait de terminer la mise au point d'un système et était en quête d'une occasion d'effectuer des essais. Le système fut expédié à Anvers en Belgique, où il fut installé à bord du N.M. Arctic. Divers ajustements et modifications aux systèmes de bord furent faits dans le but de brancher le système de Nordco, ainsi que d'assurer la qualité des données recueillies.

Le navire quitta Anvers le 8 novembre 1989, pour Nanisivik via l'Atlantique nord. La collecte de données commença le 15 novembre 1989, alors que le navire était à une latitude de 71° N, au sud de la baie de Baffin. Un grand nombre d'images radar fut stocké, représentant différentes conditions de glace, et des

paramètres opérationnels variés. Des images d'un environnement statique ainsi que dynamique furent stockées, provenant des trois sources de signaux radar à bord du N.M. Arctic soit Decca bande X, Sperry bande X (HH), et Sperry bande X (HV). La majorité des images enregistrées peuvent être comparées à des images SAR télétransmises à bord, représentant les régions d'intérêt.

Les spécifications techniques complètes de chaque fichier de données furent prises en note manuellement, et aussi répétées au début de chaque fichier. Les données recueillies sont divisées en 13 groupes, en plus d'une variété de fichiers uniques. Au total, 4 gygabytes de données furent stockées sur ruban magnétique vidéo 8 mm, utilisant une unité de stockage numérique EXABYTE(R). L'objectif auquel est destiné chaque groupe de données est exposé et quelques suggestions sont faites au sujet d'analyses supplémentaires des données recueillies.

Les données recueillies forment un ensemble d'images radar d'une précision et d'une résolution sans précédent. Les données totalisent plus de 4 gigabytes d'information brute qui peut être analysée pour extraire l'information qu'elle contient. Aucun traitement des données n'a été effectué et l'information n'a nullement été altérée. La gamme complète des méthodes d'analyse peut être utilisée, à partir de la méthode de conversion de balayage la plus simple jusqu'aux techniques de traitement d'images les plus sophistiquées.

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1.0 Introduction

Canarctic Shipping has led the development of the SINSS (Shipboard Ice Navigation Support System) for the last five years. One of the major components of the SINSS technology is the marine radar image processing and display system. Many manufacturers and research organizations have undertaken the development of radar scan converters for the purpose of marine navigation, yet, none have specifically addressed the ice navigation requirements. All developments have been guided by open water navigation requirements, which are in opposition to ice navigation requirements. The present radar data collection effort is aimed at collecting data specifically for the purpose of ice navigation radar developments.

Up to now, no commercial or research equipment was available to collect high bandwidth radar data images. Analog tape recorders were often used but these are bulky and have limited dynamic range and signal bandwidth capability. Finding a suitable system to record the required radar images was difficult and only one system was identified as capable of collecting the required radar data. Under a government-sponsored technology development program, Nordco Company Ltd. of St. John Nfld, developed a marine radar image collection system capable of collecting high quality, wide bandwidth data. Nordco was contracted by the Transportation Development Centre to collect radar data images from the Arctic Marine Radar system located on the M.V. Arctic, during the vessel's November voyage to the eastern Canadian Arctic.

The late November commercial trip of the M.V. Arctic to the Canadian Arctic was chosen as an ideal period for collecting a marine radar data set of a variety of new ice conditions. The November time period corresponds to the incursion of high concentrations of multi-year ice into the entrance of the Lancaster Sound from Northern Baffin Bay, across the vessels

route. These ice conditions, only prevalent in the early winter period, warrant the use of airborne Synthetic Aperture Radar (SAR) images downlinked to the vessel, to assist in navigation. The SAR images thus provide a complementary data set to aid in the characterization of the collected marine radar images. As a result, images of open water returns, first year ice, multi-year ice and land masses were collected, a large portion of which are correlated to a dedicated SAR mission flown over the study area.

2.0 Project Objective

The goal of the project was to collect unprocessed radar video signals from the three marine radars on board the M.V. Arctic, under various ice conditions and radar settings. The data collection focused on providing data to continue technology developments in key areas that impact on ice navigation and provide some measure of comparative characterisation of the different radars on board the ship.

The key technology developments in ice navigation, where the data will be of value, are the following:

1) The development of radar image mapping techniques.

2) The use of mathematical processing to increase the resolution of radar images of ice in the far range.

3) The continued development of marine radar image enhancement for the purpose of correlation with the airborne SAR imagery.

4) The investigation of the benefits of cross polarized radar signals for hazardous ice condition detection.

5) Investigation of the limiting factors of range for marine radar images of ice and the relative contributions of antenna beam width and low grazing angle.

The characterization goals were:

1) Characterize the advantages of higher transmitted power and lower noise front end receivers.

2) Characterize the advantages of shorter pulse width for ice navigation.

3) Characterize the relative intensity of signals received on the HV compared to the HH channel.

3.0 Scope

This report describes the installation of the radar data collection hardware, the adjustments and modifications to the marine radar systems, and a full description of the collected data sets.

4.0 Method

4.1 Equipment Installation

The Nordco data collection hardware consists of two serial communication terminals, a high definition colour monitor for data display, and one 19" equipment rack containing the computer

system. This collection system was complemented by field support equipment and spares, taken on board to provide some measure of redundancy. The equipment was flown to Antwerp Belgium where it was installed on the bridge of the M.V. Arctic.

Figure 1 and Figure 2 show the completed installation in the research area of the starboard bridge wing. In order to complete the installation, one equipment rack, already installed in this area, was removed and replaced by the Nordco system. The monitors and other display equipment were mounted on the desk located nearby. Figure 3 shows a plan view of the bridge in this area.

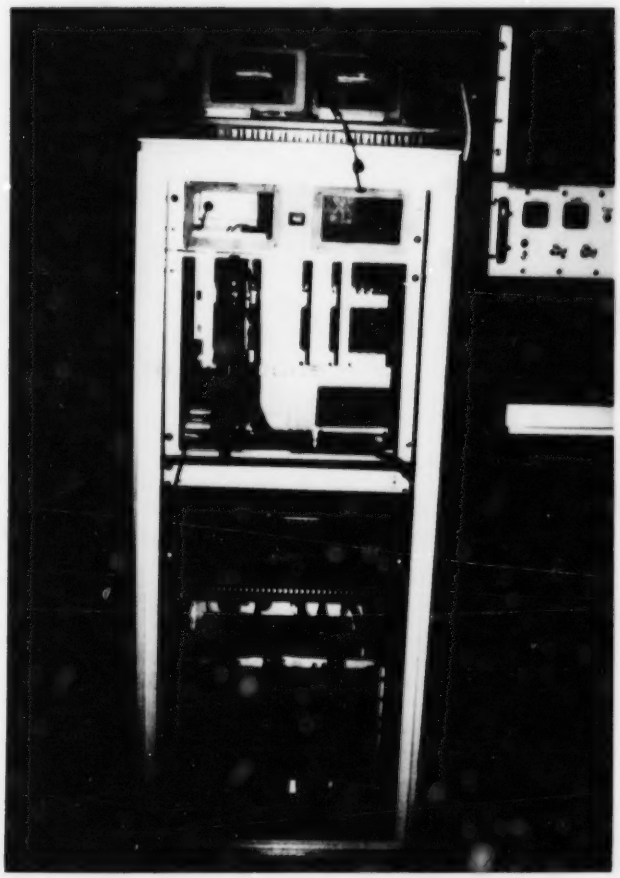


Figure 1:
Radar Data Acquisition System Installed in Research Area of M.V. Arctic

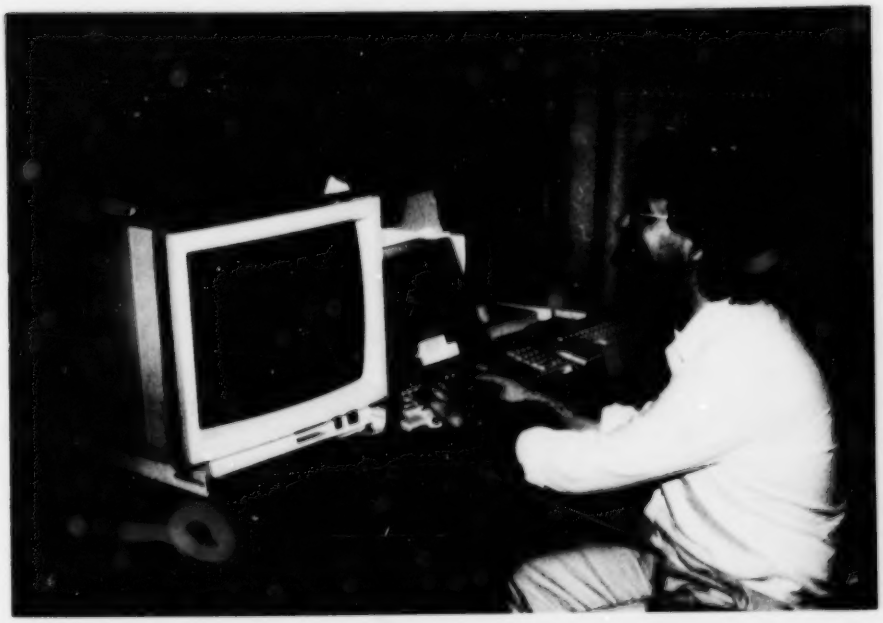


Figure 2: Data Acquisition System Control and Display Terminals

Prior to the voyage, it was determined that the appropriate way to connect the data collection system to the onboard radars was to use the Canarctic RDS (Radar Display Selector) built for this purpose two years ago. The antenna azimuth signal format at the output of the RDS was not directly compatible with the Nordco system, therefore, a special synchro to digital transformer and a step up voltage transformer were used to adjust the signal levels to the desired values. Some modifications to the RDS were also necessary to complete the connection process. The video and trigger signals were adjusted to take advantage of the recorder's full dynamic range thus providing the best possible data resolution.

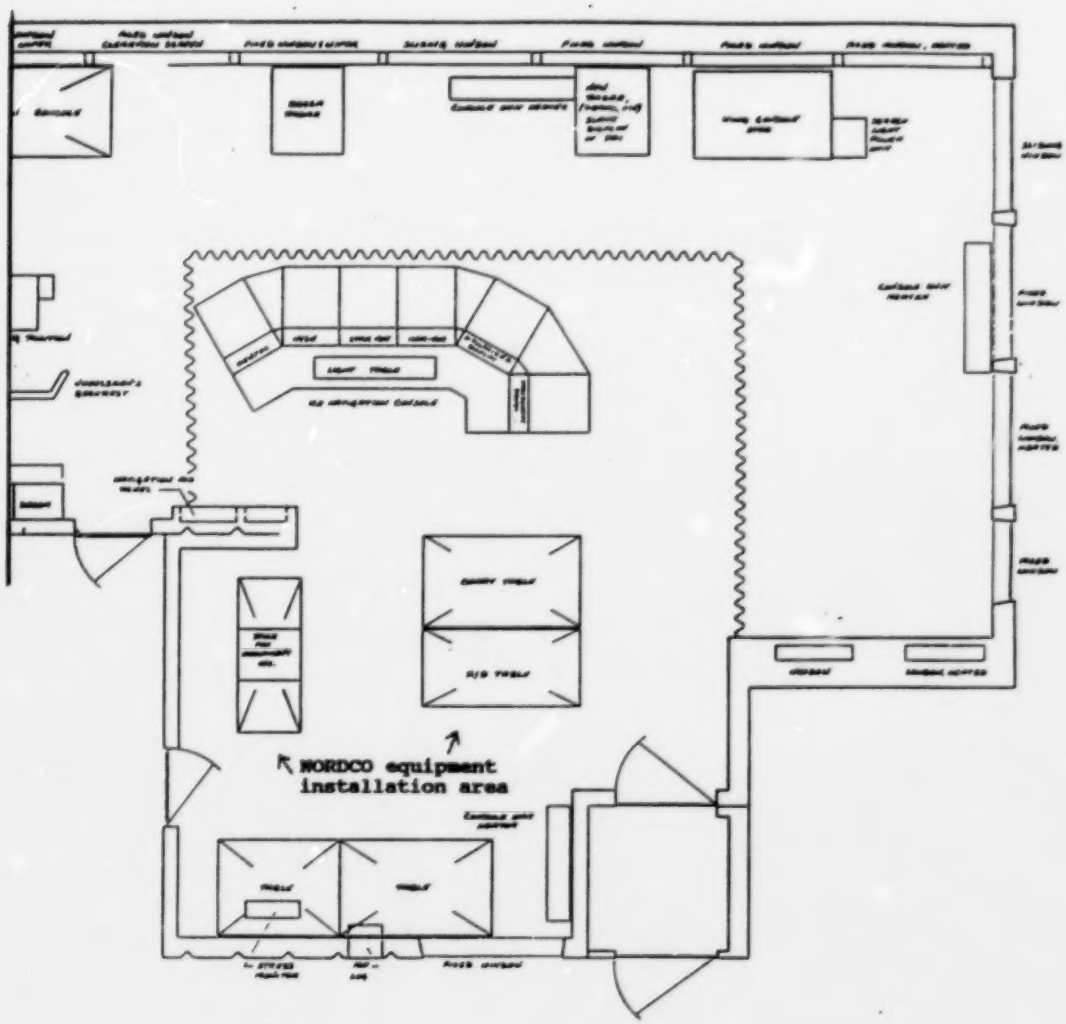


Figure 3: M.V. Arctic Starboard Bridge Area

It was determined that at least one of the data sets would require slow antenna turning rates. The Sperry antenna is driven by a 3 phase, 220 Volts motor which sets the antenna turning rate at 2.5 seconds per revolution. The speed of this motor can be varied using a solid state variable speed motor drive. One of

the shipboard systems, not in use for the duration of the data collection project, is fitted with such a controller. The controller was temporarily removed from the onboard equipment and installed on the Sperry radar system. It was found that the speed of the scanner could easily be changed from 5% to 110% of the antenna nominal speed. This flexibility proved invaluable for the collection of most data sets. The installation of the Nordco equipment was completed while the vessel was in port, after which the equipment was tested and determined to operate properly.

4.2 Adjustments

In order to help reduce ghost echoes generated when high PRFs (Pulse Repetition Frequency) are used, the PRF was reduced in the transceiver unit by approximately 10%.

In order to provide a signal containing the base line noise (necessary for scan to scan integration) the receiver video clipping level was adjusted below noise level. It was found that the full receiver dynamic range could only be obtained when the gain adjustments were set to maximum. However, this gain setting caused the Sperry display to saturate, masking targets from the operator. The radar video level was thus reduced at the input of the Sperry display unit to compensate for the high gain settings required for good quality image recordings.

A logic analyzer was used to determine the offset angle between the ship's head and the antenna synchro azimuth signal zero point. The analyzer was connected at the output of the 14 bit synchro to digital converter, and the heading marker signal used as a trigger input. The offset was determined to be 33.22° from the ship's head.

5.0 Data Collection

Most of the radar images were collected in Baffin Bay, at a latitude north of 70°N. At that position, the ice conditions were not considered difficult and the ship was able to proceed easily at a speed of 12 knots. The ice conditions became progressively more difficult as the ship proceeded further north. The vessel encountered a multi-year ice field east of the entrance of Lancaster Sound which prompted the decision to stop and wait for SAR imagery to help evaluate the route to be taken to Nanisivik. Engine problems forced the ship to stop for a period of 36 hours, 50 nautical miles south east of the position where the downlink of airborne SAR imagery was planned to occur.

The primary purpose of the program was to acquire marine radar images with identifiable features such as ice floes, ridges, open water leads and icebergs. It was not the intent of the program to collect radar images only of ice conditions limiting the vessel's advance. Therefore, the data collection began well before limiting conditions were encountered by the vessel. Although very few multi-year ice floes were encountered until the ship reached the downlink location, the collected radar images are considered suitable for ice navigation research purposes.

A static environment (where the ship was stationary) for data collection was available twice; during the engine repairs and while waiting for SAR imagery. A SAR flight line was plotted and received, that correlated to the recorded marine radar imagery. Figure 4 shows Baffin Bay with the plotted ship's route, the main radar data sets, and the SAR flight line location.

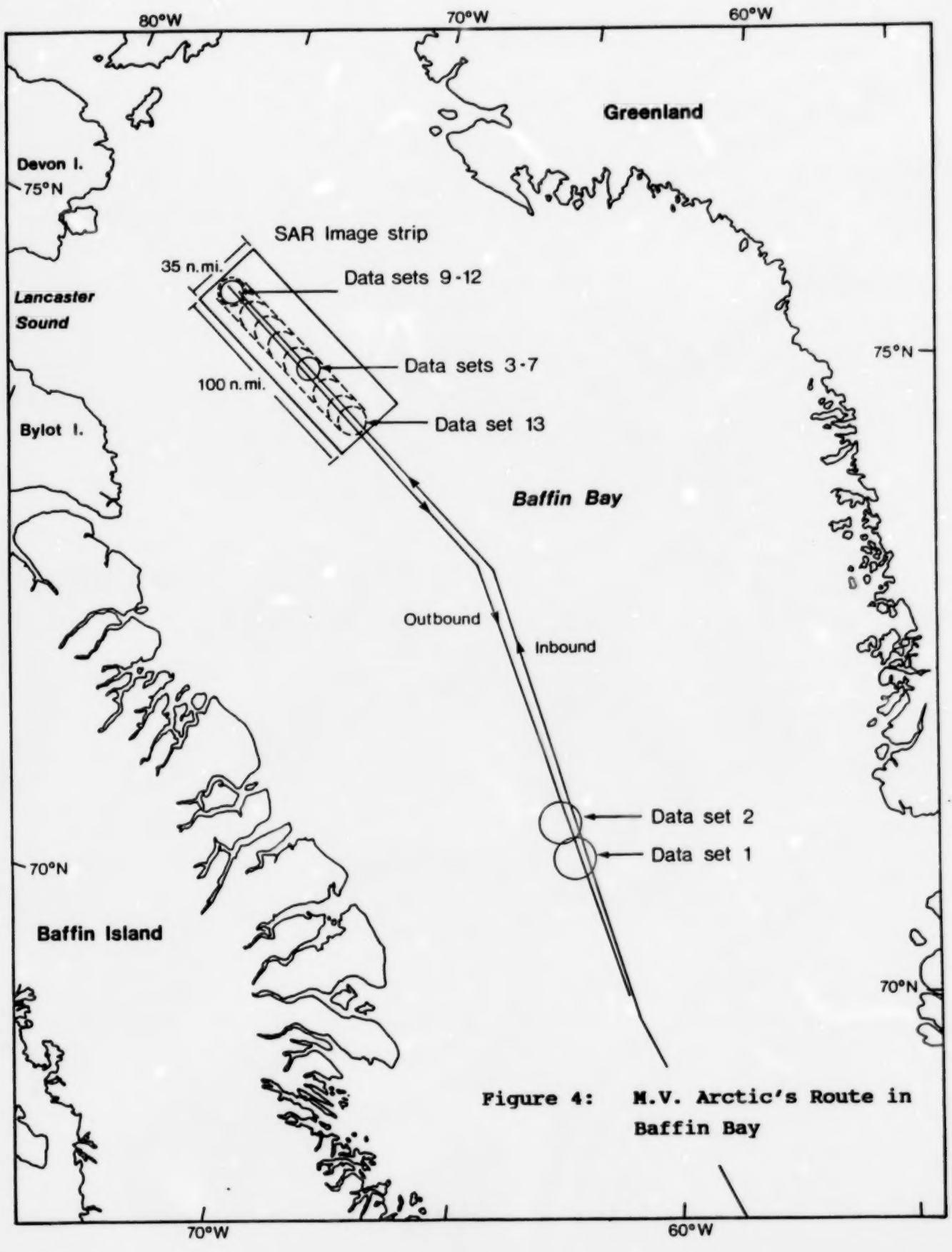


Figure 4: M.V. Arctic's Route in Baffin Bay

5.1 Radar Data Sources

Three radar signal inputs were available for data collection:

1) The Sperry X-Band Horizontal polarized channel (HH)
2) The Sperry X-Band Vertical polarized channel (HV)
3) The Decca X-Band channel

The main characteristics of the above radars are given in Table 1. Figure 5 shows the radar system configuration on board the M.V. Arctic.

Table 1

	Decca	Sperry (HH, HV)
PRF (Hz)	3,200	2,910
Antenna turning rate (min)	3.5 sec/rev	fully adjustable
Pulse width (min)	50 nS	70 nS
Transmitted power	25 Kw	50 Kw
Video polarity	neg/log	neg/log
Video bandwidth (max)	16 Mhz	6.0 Mhz

5.2 Data Collection System

The data collection system consists of a computer system based on the VME architecture, capable of sampling data at a rate of up to 40 Mhz, with a resolution of 10 bits (1024 discrete levels). Because of internal memory limitations and disk data transfer rate, the range of the images was limited to approximately 6.3 Nm from start of sampling. Images to be collected with a range greater than 6.5 nautical miles were collected in two concentric images, the outer ring having a

doughnut-like shape. The start and end of the scan digitization are fully programmable such that sectors of any desired angle can be captured and stored.

Depending on radar antenna turning rate and digitizing frequency, a maximum of approximately 3 full scans could be digitized in one data file. The data is stored on 8mm video tapes, using an EXABYTE(R) digital data storage tape drive. The tapes can store in excess of one Giga bytes of information and are thus ideal for this kind of application.

5.3 Choice of Pulse Width

The primary purpose of the data collection effort was the production of high quality, high resolution radar images. For this purpose, the shortest available pulse length, consistent with high resolution, was selected on all radars during most of the data collection. A few images were collected at longer pulse width, but only for the purpose of comparing to shorter pulse width images, and not for image production purposes.

5.4 Antenna Turning Rate

During the scan conversion process, radial samples will be mapped to a cartesian coordinate system. During the course of this process, care was taken to "fill" each pixel location in the cartesian coordinate system. If the PRF (Pulse Repetition Frequency) or the antenna TR (Turning Rate) are two low, data items needed for direct conversion will be missing and, therefore, would have to be reconstructed from existing data. The reconstruction of missing pixels in the image periphery is necessary in order to avoid Moire pattern production.

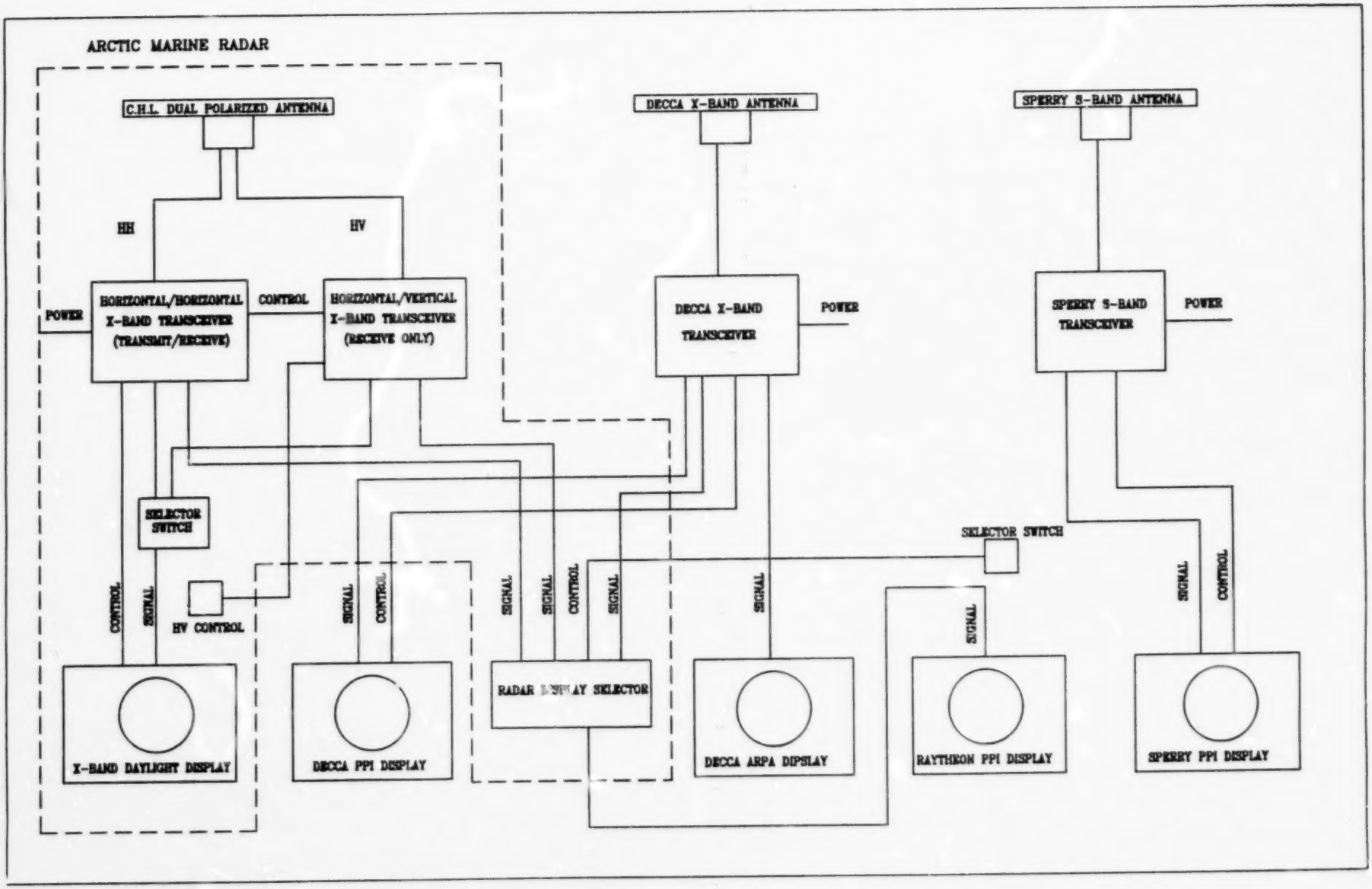


Figure 5: M.V. Arctic, Marine Radar System Configuration

In order to avoid this problem, the radial density must be increased to match the sampling density at the image periphery. The following calculations lead to the determination of the desired antenna turning rate, given a range of 6 nautical miles:

Range (R) = 6 Nm
Sampling rate = 20Mhz
PRF = 2.91Khz
TR = ?

1Nm => 12.35 uS
20Mhz => 50nS data sampling period
50nS => 4.049 E-3 Nm/sample

(1) $a = R d\theta$
(2) $d\theta = a/R$

where: a = length of arc between two successive radials at maximum range
$d\theta$ = angle between two successive radials (for small angles)

(3) $$d\theta = \frac{2\pi}{PRF \times TR}$$

(2)=(3) => (4)

(4) $$\frac{a}{R} = \frac{2\pi}{PRF \times TR}$$

(5) $$TR = \frac{2\pi R}{a \times PRF} = \frac{2\pi \times 6.0}{4.049E\text{-}3 \times 2{,}910} = 3.2 \text{ sec}$$

These calculations indicate that an antenna turning rate of a maximum of 3.2 seconds per revolution is necessary to achieve a polar data density equivalent to the radial density at maximum range. For most of the data collection, the antenna turning rate was set at, or slower than 3.2 sec per revolution. Mapping conversion from polar to cartesian can thus be easily performed, without the need for extrapolation at far range. The obtained data density carries other benefits than ease of scan conversion that are not relevant to this report but were a consideration in

setting the antenna turning rate. An example of this is radar interference rejection processing, that benefits from high density data.

6.0 Data Sets

As outlined in the introduction, the primary intent of the data collection was to provide data for ongoing developments in key areas of ice navigation, as well as characterisation of the radars on the M.V. Arctic. However, the value of the characterisation data set is limited, since no calibrated targets or transmitted signals were available. It is believed that certain data sets that were collected will be sufficiently large to allow statistical analysis of the data and the extraction of meaningful and accurate information. Table 2 lists the collected data sets by number with the corresponding filenames. A complete description of the data files and the corresponding radar settings can be found in appendix A.

Table # 2: Data Set Files

Set #	Sperry HH	Sperry HV	Decca
1	SPIH0021 - SPIH0035		
2	SPIH0038 - SPIH0042		
	SPIH0037 - SPIH0040 (Duplicate file names, different data)		
3	SPIH0053 - SPIH0062		
4		SPIV0051 - SPIV0060	
5		SPIV0065 - SPIV0074	
6	SPIH0063 - SPIH0066		
7			DECIH0053 - DECIH0062
8	---------- DATA LOST ----------		
9	SPIH0076 - SPIH0078	SPIV0075 - SPIV0077	
10	SPIH0086 - SPIH0088	SPIV0081 - SPIV0083	DECIH0079 - DECIH0081
11	SPIH0089 - SPIH0091	SPIV0084 - SPIV0086	DECIH0082 - DECIH0084
12	SPIH0092 - SPIH0093	SPIV0087 - SPIV0089	DECIH0085 - DECIH0087
13	SPIH0109 - SPIH0178	SPIV0108 - SPIV0170	

In addition to the specific results expected from the analysis of the dedicated data sets, general analysis of all the data sets will provide additional information, albeit of a lesser nature. For example, the video bandwidth of the respective radars can be inferred by the fourier transform of the radar signals, followed by the statistical analysis of the results. The same process repeated on many images will improve the accuracy of the calculated figures. In addition, many images were collected that are not specifically part of a data set, but contain information that can be useful. Appendix A further details these data files.

6.1 Ice Navigation Data Sets

1) Radar Mapping Data Set

Radar image mapping has been determined to be one the most promising methods of increasing the radar/SAR correlation area now limited to 3 nautical mile range. A large body of the collected data set will be used to develop and evaluate different techniques of mapping radar imagery. For this purpose, the following image files have been collected:

Set # 1: SPXH0021 TO SPXH0035
Set #13: SPXH0109 TO SPXH0178
SPXV0108 TO SPXV0170

Set # 1 consists of 15 images taken at .25 nautical mile interval, with a range of 3 nautical miles.

Set #13 consists of 122 image files of alternate HH and HV Sperry X-Band images. These images have a range of 6 nautical miles, and were taken at an interval of approximately .33 nautical miles over a track that is over 100 nautical miles. The SAR flight line is fully correlated to this data set.

2) High Resolution Data Set

In order to effectively correlate the radar image of the ice surface to the SAR imagery, the far range angular resolution must be improved. The antenna aperture now limits the high definition range to 2 nautical miles or less. A certain quantity of data has been collected to investigate the possibilities of increasing the resolution without changing the antenna characteristics, using mathematical processing.

A series of 9 images have been recorded while the ship was in motion, in very high resolution mode. They consist of 90° sectors with an extremely high radial density. For this data set, the antenna rotation rate was reduced to 16 seconds per revolution while the range was limited to 3 nautical miles because of internal system memory limitations. The images were taken at an interval of .5 nautical miles so that the processed images can be compared with high resolution, short range images of the same area. The data files are:

Data set # 2: SPXH0038 TO SPXH0042
SPXH0037 TO SPXH0040

These files have duplicate labels because of an error in the operating system that caused the file counter to reset to 0037 after the system crashed. These files are sequential on the tape, and even though they share the same name, the time stamp on each file is different and therefore the data can be recovered.

3) Image Enhancement Data Set

Sponsored by the Transportation Development Centre, Cimmetry Systems of Montreal Que, has been conducting research in radar image enhancement to improve radar/SAR image correlation. A large body of the data sets collected during the project will be used to refine and test enhancement techniques developed by Cimmetry, and the way to use them for ice navigation in the SINSS environment.

Most of the images can be used to continue developments in the area of image enhancement. However, images that are correlated to SAR imagery are of particular interest. These files are:

Data Set # 9: SPXH0076 TO SPXH0078
SPXV0075 TO SPXV0077

Data Set # 13 SPXH0109 TO SPXH0178
SPXV0108 TO SPXV0170

4) Ice Detection Data Set

The recent installation on board the M.V. Arctic of a cross polarized antenna, provides an additional signal that can be used for enhanced ice detection. The advantages gained by using such a radar signal for hazardous ice detection must be investigated. A large quantity of HH and related HV data has been collected to characterise the relative performance of these two data channels. Any data set containing simultaneous images of HH and HV data can be used for that purpose. Some examples of these files are:

Data Sets #3 through #7, and Data Sets #9 through #13

5) Long Range Data Set

In order to increase the radar useful range for ice mapping, a data set has been collected to determine if the limitation in range is either an effect of loss of return or antenna beam width, or both. Scan to scan averaging on a large scale will be used to determine this. For this purpose, data sets #3 through #7 have been collected. Taken together, these data sets constitute 10 images of a static environment, from all three radar sources, extending to a range of 12 nautical miles.

6.2 Characterization Data Sets

1) Power Characterization Data Set

The range increase and discrimination improvements provided by increased power transmitters and low noise figure receivers can be evaluated by recording a number of scans of a static environment, from a high power and a low power radar. Such a data set was collected while the ship was stopped for engine repairs and consists of data sets #3 through #7.

2) Pulse Length Characterization Data Set

The improvement in resolution provided by short pulse lengths and high bandwidth video signals can be determined by recording images from each radar, at a 40Mhz digitizing rate. This high digitizing rate will allow calculations to be performed to the full bandwidth of the available signals. Data sets #9 through #12 can be used to perform these calculations.

3) HH HV Intensity Characterization Data Set

The relative intensities received from both HH and HV channels can be evaluated statistically if a large volume of correlated HH and HV images are available. Such data sets have been collected over a large area, under various ice conditions. Any data set containing both HH and HV images can be used for this purpose, such as set #3 to #7, or #9 and upwards.

6.3 General Data

In addition to the above mentioned data sets, numerous images have been collected in different sea environments at various radar settings. Although of lesser interest for the purpose of ice navigation investigations, this data can be used to further

characterise the performance of the various radars on board the M.V. Arctic. A full description of the parameters of these images, as well as the other data sets, is given in appendix A.

7.0 Discussion and Conclusion

The collected data constitute an unprecedented set of high precision and high bandwidth radar information. This data set consists of more than 4 gigabytes of raw radar video information that can be processed to extract the desired information. No processing has been performed on this data, and it has not been altered in any way. Analysis of the collected information can now be undertaken, using processing that ranges from different scan conversion techniques to the most innovative image processing algorithms.

The quantity of data and the its quality, will require massive computing time and resources on a state of the art hardware base. The simple task of retrieving the information from the storage tapes and accessing it will require by itself a system having large amounts of live memory, high processing speed, and a high resolution display. In order to facilitate the dissemination of the collected data, it may be desirable to have representative data files scan converted and transferred to more convenient storage media. In this way, small scale dedicated analysis of portions of the collected data may be performed.

The analysis of the collected data will provide the kind of information that will help define future systems and refine radar image enhancement methods. The high definition of the collected data will set new standards for ice navigation radar displays. The resolution of the crude images produced by the system during data collection, was far in excess of any picture displayed by

any system on board the ship at that time. In fact, the resolution was better than what can be provided by any commercially available system on the market today.

The collected data was made as diverse as possible, given the capabilities of the system, and the relatively short time available before the data collection effort. However, the data set is only representative of the intent behind it and the analysis it is intended to feed. Many examples of possible processing were given within this report. There is no doubt that investigators actively involved in other aspects of radar research will find other ways of extracting meaningful information from the collected data set.

The data collection system only became operational days before the trip. The primary intent of the system was slightly different than what it was used for during this project. However, sufficient flexibility had been included in the design to allow the system to complete the required task. Problems encountered during the data collection and deficiencies in the operating parameters were duly noted by Nordco. Corrections will be made to the design to make the system more flexible and capable of higher performance. It is hoped that this data collection will be repeated next year using the improved version of the system and a data collection schedule addressed to a wider audience.

Appendix A

Data Set Parameters

1.0 Data Set Storage Format

The radar data has been stored on 8mm video tapes, using an EXABYTE(R) digital data storage tape drive. The recorded data is 10 bits wide and is recorded in a 32 bit packed word format and thus requires 4 bytes of storage for each 3 samples. The recording system is capable of storing multiple scans in each data file, depending on digitization rate and maximum range. However, the collected images have been limited to one full scan only and thus represent a "snap shot" of the radar environment. The images are stored unprocessed for scan conversion, and thus require more storage space than converted raster images. Typically, image files will contain the following amount of data:

Sampling rate = 20 Mhz
Antenna turning rate = 3.5 seconds/rev.
Pulse repetition frequency = 2.91 Khz
Data sampling duration (6 Nautical miles) = 75 uSec.

Total samples/scan = 2,910 x 3.5 x 2E7 x 75E-6 = 15.28 Msamples
Total number of data bytes = 15.28/3 x 4 = **20.37 Mbytes/image**

Even though the EXABYTE tapes can contain up to 1 Gbytes of data, the amount of storage has been limited to approximately 630 Mbytes per tape. The data is formated as follows (as outlined in a document provided by Nordco):

> The radar data is written on the EXABYTE tapes as a series of data files, each of which consist of a series of 1 KiloByte blocks terminated by a single end-of-file marker.

The first block in each file is a header containing information about the file. The block structure is best described by reproducing here the C program structure used to write it:

```
struct FILE_HEADER {
   lword init_verify;    /* 32 bit unsigned value set to 12345678 hex
                            to indicate that this is a valid file
                            header. */
   char start_time[9],   /* The time that the data was collected, in
                            an ASCII string of format
                            'HR:MN:SC'<null>.  The system clock during
                            the trip was set to GMT, except for
                            perhaps the data collected in Antwerp
                            harbour, when the clock was set to
                            Newfoundland Standard Time. */
      end_time[9],       /* Not used for this data collection. */
      date[9],           /* The date that the data was collected, in
                            an ASCII string of format
                            'MN/DY/YR'<null>. */
      filename[9];       /* 8 character null terminated filename */
   long nblock;          /* Number of 1K blocks of data in the file */
   int start_range,      /* Value used by the range gating circuit to
                            start collecting data.  This value should
                            also appear on the log sheets for the
                            file.  This value had to be entered by the
                            operator at the time of recording, since
                            the VME computer and the computer doing
                            the range gating were not connected during
                            this trip.  If there is a discrepancy
                            between the log sheet and the value in
                            the file  header, the log sheet is most
                            likely to be correct.  The same holds true
                            for the values of end range, start and end
                            azimuth, sample frequency, PRF, and the
                            filter used.  */
      nprfs,             /* Number of PRFs in a file. */
      end_range,         /* Valued used to stop range gating */
      start_azimuth,     /* Value used to start azimuth gating */
```

```
        samp_frequency,    /* Sample frequency used for the data
                              collection.  A value of 0 indicates a
                              sampling frequency of 5Mhz, 1 = 10Mhz, 2 =
                              20Mhz, and 3 = 40Mhz.  */

        prf,               /* The pulse repetition frequency of the
                              radar during the data collection.  */

        filter,            /* The filter used on the analog front end
                              during this data collection.  Value of 0
                              indicates 1Mhz cutoff, 1=4Mhz, 2=6Mhz,
                              3=15Mhz.  */

        gyro;              /* The ship's heading during the data
                              collection (again entered by hand at the
                              time of collection).  */

    char reserved[962];    /* Left over space in the 1K block */
};
```

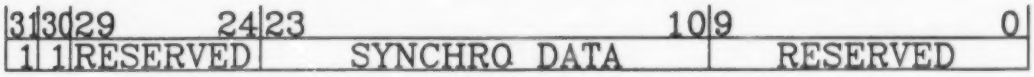
For the data collection system, an int value is a 16 bit number, and a lword value is a 32 bit unsigned value.

The actual data begins in the second block of each file. The data is divided into what is refered to as "PRFs". A PRF is the set of data corresponding to one pulse of the radar. Each PRF consists of a stream of video data terminated by the synchro value denoting the angle the antenna was at for that pulse.

The video data consists of 10 bits samples packed into 32 bit words as follows:

where sample 1 is the earliest in time. Note that the upper two bits of each 32 bit word in the video data are set at zero.

The synchro information, inserted at the end of each PRF, is a 14 bit value placed into a 32 bit word as follows:



Note that the upper two bits of the 32 bit synchro word are set to 1, so that it can easily be distinguished from the video data. The synchro word is repeated twice after each PRF, for reasons buried in the history of the design of the hardware. Therefore, after finding the synchro value at the end of the PRF, the next 32 bits have to be skipped in order to get to the beginning of the next PRF. The offset of the synchro data with relation to the ship's head, was determined to be between 3A16 Hex and 3A1B.

The same patern is repeated throughout the file. Because the file consists of 1Kb blocks, the last block in the file may be only partially filled since the lenght of the data is not necessarily a multiple of 1Kb.

RADAR IMAGE PARAMETERS (Data Sets 1 through 12)

DATA SET	FILE NAME	PRF (Khz)	PULSE WIDTH (nSec)	ANT/ROT RATE (sec/rev)	AZ. GATE (HEX)	RANGE GATE (HEX)	SAMPL. RATE (Mhz)	HEAD. (DEG.)	RANGE (N.M.)	SHIP SPEED (Knots)	
1	SPXH0021-35	2.91	70	3.2	1-3FFF	1-2E4	20	333.8	2.995	9	
2	SPXH0038-42	2.91	70	16		1-2E4	20	333.0	2.995	9	
	SPXH0037-40	(These duplicate file names result from a system crash, but the data is retrievable. Same parameters as above)									
3	SPXH0053-62	2.91	70	3.5	1-3FFF	1-650	20	279	6.54	stopped	
4	SPXV0051-60	2.91	70	3.5	1-3FFF	1-650	20	279	6.54	stopped	
5	SPXV0065-74	2.91	70	4.76	1-3FFF	600-C0E	20	279	6.22-12.49	stopped	(Outside doughnut, matches set #4)
6	SPXH0063-66	2.91	70	4.76	1-3FFF	600-C0E	20	279	6.22-12.49	stopped	(Outside doughnut, matches set #3)
	SPXH0070-75	2.91	70	4.76	1-3FFF	600-C0E	20	279	6.22-12.49	stopped	(Outside doughnut, matches set #3)
7	DEXH0053-62	3.3	50	3.0	1-3FFF	1-650	20	273.5	6.54	stopped	
8	This data set was lost due to tape error.										
9	SPXH0076-78	2.91	70	3.25	1-3FFF	1-650	40	25	3.27	stopped	
	SPXV0075-77	2.91	70	3.25	1-3FFF	1-650	40	25	3.27	stopped	
10	SPXH0086-88	2.91	70	3.25	1-3FFF	1-650	40	25	3.27	stopped	
	SPXV0081-83	2.91	70	3.25	1-3FFF	1-650	40	25	3.27	stopped	
	DEXH0079-81	3.3	50	3.5	1-3FFF	1-650	40	25	3.27	stopped	
11	SPXH0089-91	2.91	70	3.25	1-3FFF	1-650	40	25	3.27	stopped	
	SPXV0084-86	2.91	70	3.25	1-3FFF	1-650	40	25	3.27	stopped	
	DEXH0082-84	3.3	50	3.5	1-3FFF	1-650	40	25	3.27	stopped	
12	SPXH0092-94	2.91	70	3.25	1-3FFF	600-C0E	40	25	3.1-6.25	stopped	
	SPXV0087-89	2.91	70	3.25	1-3FFF	600-C0E	40	25	3.1-6.25	stopped	
	DEXH0085-87	3.3	50	3.5	1-3FFF	600-C0E	40	25	3.1-6.25	stopped	

RADAR IMAGE LOCATION PARAMETERS (Data Sets 1 through 12)

DATA SET	DATE	START TIME (SHIP LOCAL)	LATITUDE	LONGITUDE	COMMENTS
1	15/11/89	15:18:31h	70° 57'N	63° 04'W	15 sequential files at 1/4 mile interval
2	15/11/89	16:43:00h	71° 10'N	63° 38'W	9 sequential files at 1/2 mile interval, high definition 90° sectors
3	16/11/89		74° 23'N	72° 13'W	10 still images to match with outer ring (set #6)
4	16/11/89		74° 23'N	72° 13'W	10 still images to match with outer ring (set #5)
5	16/11/89		74° 23'N	72° 13'W	10 still images. Outer rings to match set #4)
6	16/11/89		74° 23'N	72° 13'W	10 still images. Outer rings to match set #3)
7	16/11/89		74° 23'N	72° 13'W	10 still images of Decca X-Band.
8	Data lost.				
9	18/11/89	11:10h	74° 50'N	75° 03'W	3 still images of each Sperry channel, digitized at 40 Mhz.
10	18/11/89	11:30h	74° 50'N	75° 03'W	3 still images of each radar source, digitized at 40 Mhz.
11	18/11/89	12:50h	74° 46'N	75° 12'W	3 still images of each radar source, digitized at 40 Mhz.
12	18/11/89	13:00h	74° 46'N	75° 12'W	3 still images of each radar source, taken at 40 Mhz. Outer rings that match sets #9,10,11.

DATA SET #13 IMAGE PARAMETERS

FILE NAME	RANGE (N.M.)	START TIME	SPEED (KNOTS)	HEADING (DEG.)	LAT(N)	LONG(W)	COMMENTS
SPXH0109	6.54	08:36	7.0	132	74° 48.0'	75° 00.0'	
SPXH0110	6.22-12.49	08:39	7.0	131	74° 48.0'	75° 00.0'	
SPXH0111	6.54	08:42	7.0	131	74° 48.0'	75° 00.0'	Wrong file name, actually HV data.
SPXV0108	6.22-12.49	08:45	7.0	131	74° 48.0'	75° 00.0'	
SPXH0112	6.54	08:57	5.9	116	74° 46.0'	74° 54.0'	
SPXH0113	6.22-12.49	09:00	6.5	112	74° 46.0'	74° 53.0'	
SPXV0109	6.54	09:03	6.7	110	74° 46.0'	74° 59.0'	
SPXV0110	6.22-12.49	09:05	7.6	112	74° 46.0'	74° 59.0'	
SPXH0114	6.54	09:15	9.0	105	74° 46.0'	74° 58.0'	
SPXH0115	6.22-12.49	09:19	9.5	112	74° 46.0'	74° 57.0'	
SPXV0111	6.54	09:22	11.5	114	74° 46.0'	74° 57.0'	
SPXV0112	6.22-12.49	09:24	10.2	118	74° 46.0'	74° 56.0'	
SPXH0116	6.54	09:36	9.2	98	74° 44.4'	74° 40.0'	
SPXH0117	6.22-12.49	09:39	10.6	92	74° 44.5'	74° 39.0'	
SPXV0113	6.54	09:41	10.0	92	74° 42.7'	74° 33.0'	
SPXV0114	6.22-12.49	09:43	8.5	88	74° 42.7'	74° 32.6'	
SPXH0118	6.54	09:58	8.6	102	74° 42.9'	74° 29.6'	
SPXH0119	6.22-12.49	10:00	6.0	102	74° 43.0'	74° 29.4'	
SPXV0115	6.54	10:02	7.2	102	74° 43.0'	74° 29.2'	
SPXV0116	6.22-12.49	10:03	7.0	103	74° 43.0'	74° 29.0'	
SPXH0121	6.54	10:19	7.0	104	74° 43.2'	74° 27.0'	
SPXH0122	6.22-12.49	10:23	8.2	108	74° 43.2'	74° 26.4'	
SPXV0117	6.54	10:25	7.0	109	74° 43.2'	74° 26.2'	
SPXV0118	6.22-12.49	10:27	7.5	110	74° 43.2'	74° 25.9'	
SPXH0125	6.54	10:44	8.7	113	74° 42.8'	74° 23.7'	
SPXH0126	6.22-12.49	10:46	8.7	113	74° 42.8'	74° 23.5'	
SPXH0127	6.54	10:48	7.5	115	74° 42.8'	74° 23.4'	Wrong file name, actually HV data
SPXV0119	6.22-12.49	10:50	7.0	119	74° 42.7'	74° 23.3'	
SPXH0128	6.54	11:00	7.5	114	74° 42.6'	74° 22.8'	
SPXH0129	6.22-12.49	11:02	6.2	114	74° 42.6'	74° 22.8'	
SPXV0120	6.54	11:04	6.9	116	74° 42.6'	74° 22.8'	
SPXV0121	6.22-12.49	11:07	7.7	116	74° 42.6'	74° 22.7'	
SPXH0130	6.54	11:17	8.0	117	74° 37.7'	73° 49.4'	
SPXH0131	6.22-12.49	11:19	8.8	117	74° 37.6'	73° 49.1'	
SPXV0122	6.54	11:21	9.5	118	74° 37.6'	73° 48.9'	
SPXV0123	6.22-12.49	11:23	10.0	117	74° 37.6'	73° 48.5'	
SPXH0132	6.54	11:33	8.0	115	74° 36.1'	73° 40.9'	
SPXH0133	6.22-12.49	11:35	12.1	116	74° 36.1'	73° 40.9'	
SPXV0124	6.22-12.49	11:37	12.4	117	74° 36.0'	73° 40.7'	
SPXV0125	6.54	11:42	12.9	117	74° 36.0'	73° 40.2'	
SPXH0134	6.54	11:55	8.2	117	74° 35.7'	73° 38.4'	
SPXH0135	6.22-12.49	11:58	8.2	118	74° 35.9'	73° 29.3'	
SPXV0126	6.54	12:05	7.0	117	74° 35.8'	73° 28.9'	
SPXV0127	6.22-12.49	12:08	7.5	117	74° 35.8'	73° 28.8'	
SPXH0136	6.54	12:18	7.4	117	74° 35.7'	73° 28.4'	
SPXH0137	6.22-12.49	12:22	8.5	117	74° 34.4'	73° 19.1'	
SPXV0128	6.54	12:23	7.5	118	74° 34.4'	73° 19.1'	
SPXV0129	6.22-12.49	12:25	7.5	117	74° 34.4'	73° 19.0'	
SPXH0138	6.54	12:36	8.4	117	74° 34.1'	73° 17.6'	
SPXH0139	6.22-12.49	12:40	8.9	118	74° 34.1'	73° 17.3'	
SPXV0130	6.54	12:43	6.5	118	74° 34.0'	73° 16.7'	
SPXV0131	6.22-12.49	12:45	7.6	118	74° 34.0'	73° 16.4'	
SPXH0140	6.54	12:53	9.2	124	74° 33.5'	73° 14.7'	
SPXH0141	6.22-12.49	12:59	9.4	124	74° 33.4'	73° 14.3'	
SPXV0132	6.54	13:01	9.4	124	74° 33.4'	73° 14.1'	
SPXV0133	6.22-12.49	13:03	9.0	123	74° 33.3'	73° 13.8'	

FILE NAME	RANGE (N.M.)	START TIME	SPEED (KNOTS)	HEADING (DEG.)	LAT(N)	LONG(W)	COMMENTS
SPXH0142	6.54	13:14	9.0	124	74° 32.9'	73° 12.8'	
SPXH0143	6.22-12.49	13:16	8.4	124	74° 32.9'	73° 12.6'	
SPXV0134	6.54	13:18	8.4	124	74° 32.8'	73° 12.4'	
SPXV0135	6.22-12.49	13:20	10.3	126	74° 32.7'	73° 12.1'	
SPXH0144	6.54	13:29	10.0	124	74° 32.3'	73° 10.5'	
SPXH0145	6.22-12.49	13:31	9.6	120	74° 32.2'	73° 10.2'	
SPXV0136	6.54	13:33	9.0	120	74° 32.1'	73° 10.0'	
SPXV0137	6.22-12.49	13:38	8.4	120	74° 32.0'	73° 09.3'	
SPXH0146	6.54	13:50	9.1	128	74° 27.7'	72° 45.2'	
SPXH0147	6.22-12.49	13:53	8.5	128	74° 27.5'	72° 45.0'	
SPXV0138	6.54	13:55	7.5	128	74° 27.4'	72° 44.8'	
SPXV0139	6.22-12.49	13:55	7.0	129	74° 27.4'	72° 44.8'	
SPXH0148	6.54	14:07	6.2	130	74° 27.2'	72° 45.2'	
SPXH0149	6.22-12.49	14:10	2.0	131	74° 27.2'	72° 45.8'	
SPXV0140	6.54	14:12	2.0	130	74° 27.3'	72° 46.2'	
SPXV0141	6.22-12.49	14:14	2.0	130	74° 27.3'	72° 46.7'	
SPXH0150	6.54	14:24	8.5	129	74° 27.1'	72° 47.1'	
SPXH0151	6.22-12.49	14:27	9.0	130	74° 27.0'	72° 46.1'	
SPXV0142	6.54	14:31	8.5	130	74° 26.8'	72° 46.5'	
SPXV0143	6.22-12.49	14:34	7.2	130	74° 26.7'	72° 46.5'	
SPXH0152	6.54	14:45	6.2	133	74° 26.3'	72° 46.2'	
SPXH0153	6.22-12.49	14:49	7.8	138	74° 26.2'	72° 46.2'	
SPXV0144	6.54	14:53	7.0	134	74° 26.0'	72° 46.2'	
SPXV0145	6.22-12.49	14:55	5.4	123	74° 25.9'	72° 46.2'	
SPXH0154	6.54	15:08	8.0	104	74° 25.8'	72° 45.7'	
SPXH0155	6.22-12.49	15:11	9.0	105	74° 25.8'	72° 45.3'	
SPXV0146	6.54	15:13	8.4	100	74° 25.8'	72° 45.1'	
SPXV0147	6.22-12.49	15:15	8.4	118	74° 25.8'	72° 44.8'	
SPXH0158	6.54	15:43	8.2	120	74° 25.2'	72° 42.5'	
SPXH0159	6.22-12.49	15:45	9.0	120	74° 25.1'	72° 42.2'	
SPXV0150	6.54	15:47	9.2	117	74° 19.0'	72° 05.0'	
SPXV0151	6.22-12.49	15:48	8.9	126	74° 19.0'	72° 04.7'	
SPXH0160	6.54	16:00	7.2	127	74° 18.6'	72° 04.2'	
SPXH0161	6.22-12.49	16:02	8.3	128	74° 18.5'	72° 04.2'	
SPXV0152	6.54	15:03	7.1	128	74° 18.5	72° 04.3'	
SPXV0153	6.22-12.49	16:05	8.2	128	74° 18.4'	72° 04.1'	
SPXH0162	6.54	16:15	10.2	125	74° 18.0'	72° 02.8'	
SPXH	6.22-12.49	16:17	6.2	129	74° 18.0'	72° 02.9'	No file name
SPXV0154	6.54	16:20	9.0	121	74° 17.8'	72° 02.6'	
SPXV0155	6.22-12.49	16:22	9.6	127	74° 17.8'	72° 02.4'	
SPXH0164	6.54	16:33	6.3	126	74° 13.6'	71° 48.2'	
SPXH0164	6.22-12.49	16:35	7.4	127	74° 13.5'	71° 48.2'	
SPXV0156	6.54	16:38	8.7	128	74° 13.4'	71° 47.9'	
SPXV0157	6.22-12.49	16:40	5.4	125	74° 13.4	71° 48.0'	
SPXH0166	6.54	16:51	5.7	126	74° 13.3'	71° 48.7'	
SPXH0167	6.22-12.49	16:53	7.1	125	74° 13.3'	71° 48.8'	
SPXV0158	6.54	16:57	8.0	125	74° 13.3'	71° 49.1'	
SPXV0159	6.22-12.49	16:59	8.5	122	74° 13.3'	71° 49.2'	
SPXH0168	6.54	17:02	9.0	123	74° 12.9'	71° 48.2'	
SPXH0169	6.22-12.49	17:05	9.0	123	74° 12.9'	71° 48.1'	
SPXV0160	6.54	17:07	8.2	113	74° 12.8'	71° 47.9'	
SPXV0161	6.22-12.49	17:09	9.2	112	74° 12.8'	71° 47.7'	
SPXH0170	6.54	17.31	9.5	125	74° 12.4'	71° 45.6'	
SPXH0171	6.22-12.49	17:34	9.5	125	74° 12.3'	71° 45.4'	
SPXV0162	6.54	17:37	12.2	126	74° 12.0'	71° 44.3'	
SPXV0163	6.22-12.49	17:40	10.0	126	74° 11.9'	71° 44.0'	
SPXH0172	6.54	17:56	6.7	120	74° 11.6'	71° 44.0'	
SPXH0173	6.22-12.49	17:58	5.1	123	74° 11.6'	71° 44.2'	
SPXV0164	6.54	18:00	7.5	124	74° 11.6	71° 44.3'	
SPXV0165	6.22-12.49	18:02	7.2	123	74° 11.5'	71° 44.1'	
SPXH0174	6.54	18:15	10.3	120.3	74° 11.1'	71° 43.0'	

FILE NAME	RANGE (N.M.)	START TIME	SPEED (KNOTS)	HEADING (DEG.)	LAT(N)	LONG(W)	COMMENTS
SPXH0175	6.22-12.49	18:17	12.0	120	74° 13.0'	71° 42.3'	
SPXV0167	6.54	18:24	9.4	120	74° 10.7'	71° 40.9'	
SPXV0168	6.22-12.49	18:26	9.5	120	74° 10.7'	71° 40.6'	
SPXH0177	6.54	18:37	10.4	125	74° 10.2'	71° 38.7'	
SPXH0178	6.22-12.49	18:41	9.6	125	74° 10.0'	71° 38.1'	
SPXV0169	6.54	18:43	10.4	123	74° 09.0'	71° 37.5'	
SPXV0170	6.22-12.49	18:45	10.5	123	74° 03.2'	70° 55.9'	

For the above files, the following general parameters apply:

Pulse repetition frequency: 2.91Khz
Antenna rotation rate: 3.5 seconds/rev.
Transmitted pulse length: 70 nano seconds
System digitizing rate: 20Mhz
Date: Nov. 21, 1989

General Data Files Parameters

FILE NO.	FILE NAME	DATE	TIME	PRF (KHZ)	PLSE (NS)	RATE (MHZ)	RANGE N.M.		LAT (N)	LONG (W)
1	SPXV0002	07-11-89	19:33	3.2	70	40	2.064	Antwerp Harbour		
2	SPXV0003	07-11-89	20:11	3.2	70	20	6.54	"		
3	SPXV0004	07-11-89	"	-	-	-	-	"		
4	SPXV0005	07-11-89	"	-	-	-	-	"		
5	SPXV0008	07-11-89	"	-	-	-	-	"		
6	SPXV0009	07-11-89	"	-	-	-	-	"		
7	SPXV0010	07-11-89	"	-	-	-	-	"		
8	SPXV0011	07-11-89	"	-	-	-	-	"		
9	0006	07-11-89	"	-	-	-	-	"		
10	0001	07-11-89	"	-	-	-	-	"		
11	0001	07-11-89	"	-	-	-	-	"		
12	0002	07-11-89	"	-	-	-	-	"		
13	SPXH0002	09-11-89						at sea		
14	SPXV0007	09-11-89						"		
15	SPXH0184*	09-11-89	17:20	1.6	-	-	12	Strait of Belle Isle	52° 36.9'	57° 09.9'
16	SPXH0184*	09-11-89	"	1.6	-	-	12	"	-	-
17	SPXH0184*	09-11-89	"	1.6	-	-	12	"	52° 34.2'	57° 15.2'
18	SPXH0184*	09-11-89	"	1.6	-	-	12	"	52° 32.3'	57° 22.0'
19	SPXH0184*	09-11-89	"	1.6	-	-	12	"	52° 31.3'	57° 27.8'
20	SPXH0184*	09-11-89	"	1.6	-	-	12	"	52° 30.6'	57° 33.8'

NOTE: FOR THESE FILES, THE SPEED WAS 8.2 KNOTS AND THE COURSE 233°T